above quoted figure in its much darker colouration throughout on the upperside, more especially on the outer margins; but on the underside it is much paler.

II.—*On the Measurement of Solar Radiation by means of the black-bulb Thermometer in vacuo.—By* S. A Hill, Esq. *B. Sc. Metl. Rep. to N. W. P. and Oudh. Communicated by* H. F. Blanford, Esq. F. R. S.

[Received March 29th :—Read April 4th, 1883.]

The interesting results of sun thermometer observations, published by Mr. Blanford at page 72, Vol. LI, Part II, of the Journal of the Asiatic Society of Bengal, suggest the possibility of making use of the instrument to measure the heat received from the sun. Even with all the precautions adopted by Mr. Blanford, the excess of the maximum temperature in the sun, above the maximum in the shade, is affected by variations in the following and perhaps other conditions, as well as by variations in the heat emitted from the sun.

I. The thickness of the atmosphere traversed by the sun's rays, which, for moderate degrees of obliquity, may be taken to be proportional to the secant of the sun's zenith distance.

II. The absorptive power of the clear transparent atmosphere, which probably varies with the proportion of water vapour in it.

III. The quantity of haze and dust in the air.

IV. The radiating and reflecting powers of the ground surface in the vicinity of the thermometer.

V. The excess of the maximum air temperature above the temperature at the hour, when insolation is most intense.

The last mentioned condition is subject to a very distinct annual variation. At Allahabad, where hourly observations have been made on four days in each month since 1875, the insolation is most powerful on clear days within a few minutes of noon, while the average excess of the maximum above the noon temperature of the air is the following:

Jan.	Feb.	Mar	Apl.	May	June	October	Novr.	Decr.
3·5°	3·5°	3·9°	4·1°	3·9°	4·2°	4·3°	4·4°	2·9°

In order to obtain comparable values for the several months we should therefore add these corrections to the figures for Allahadad given by Mr. Blanford. In table I the figures in Mr. Blanford's second table are thus corrected, and the table is extended down to the end of 1882.

TABLE I.—*Excess Temperature of the Sun thermometer on clear days at Allahabad above the air temperature at noon.*

Year.	Jan.	Feb.	Mar.	Apl.	May.	June.	Oct.	Nov.	Dec.	Mean for 9 dry months.
1876	66·1°	65·7°	63·9°	60·6°	56·5°	57·3°	60 3°	64·0°	64·0°	62·0°
77	63·0	66·7	63·6	62·4	60·0	57·4	59·8	63·0	63·4	62·1
78	65·9	64·3	65·2	64·5	62·3	57·8	59·6	64·7	64·6	63·2
79	64·2	63·9	63·7	62·6	61·8	61·0	61·1	64·9	63·5	63·1
80	63·0	63·8	60 3	59·9	62·0	61·5	58·3	62·5	60·6	61·3
81	62·3	60·9	61·9	60·4	60·3	63·0	54·8	61·8	59·9	60·6
82	60·5	61·5	60 1	61·1	60·6	59·1	54·8	62·2	58·2	59·8
Mean.	63·6	63 8	62·6	61·6	60·5	59·6	58·4	63·3	62 0	61·7

Variations in the fourth condition, above specified, cannot be allowed for or corrected, unless by means of a long and troublesome experimental investigation, but those of the first, second and third conditions may perhaps be estimated by mathematical methods from observations already made. Pouillet's formulæ, it is true, has a rational basis only when it is applied to radiation of one definite degree of refrangibility; but, as an empirical rule, it probably gives results not very wide of the truth when the altitude of the sun above the horizon exceeds 40°, as it does at noon in Allahabad during every month of the year. If, then, we take α to represent the diathermancy coefficient of dry air, or the proportion of the total radiation, transmitted vertically, through a layer of dry air which produces a pressure of 1 inch ; β, the diathermancy coefficient of vapour, the tension of which is 1 inch; and γ, the proportion transmitted through an atmosphere containing dust or haze to the extent of one unit on an arbitrary scale, we have—

$$\log r = \log R + b \sec z \log \alpha + f \sec z \log \beta + d \log \gamma.$$

The proportionate number for dust and haze, d, being somewhat uncertain, there is no advantage in applying to it a correction for obliquity, especially as the vertical thickness of the dust layer is greatest in the hot weather months, when the sun's rays fall almost perpendicularly. The number for May, the dustiest month, being taken at 10, the proportionate numbers I have assigned to the other months are:

Jan.	Feb.	Mar.	Apl.	May	June	Oct.	Nov.	Dec.
3	4	7	9	10	5	0	1	3

The mean values of b and f, barometric pressure and the tension of vapour, are given in tables II and III. In strictness these should be taken only for the clear days in each month, but the means for all the days here given, are practically the same in the case of barometric pressure, and there is no difference in the pressure of vapour, of any importance, except in the month of June.

TABLE II.—*Mean Barometric Pressure; 29 inches.*

Year.	Jan.	Feb.	Mar.	Apl.	May	June	Oct.	Nov.	Dec.	Mean for 9 dry months.
1876	·681	·626	·541	·389	·300	·199	·605	·670	·787	·533
77	·795	·736	·585	·506	·369	·236	·601	·678	·733	·582
78	·771	·704	·599	·478	·380	·198	·482	·615	·693	·547
79	·723	·646	·554	·402	·274	·210	·546	·686	·717	·529
80	·679	·652	·509	·390	·305	·164	·562	·727	·768	·528
81	·779	·690	·598	·417	·326	·219	·519	·653	·743	·549
82	·751	·652	·557	·416	337	·182	·492	·689	·711	·532
Mean.	·740	·672	·563	·428	·327	·201	·544	·674	·736	·543

TABLE III.—*Mean Tension of Vapour in inches of mercury.*

Year.	Jan.	Feb.	Mar.	Apl.	May	June	Oct.	Nov.	Dec	Mean for 9 dry months.
1877	·312	·295	·356	·330	·524	·744	·678	·447	·343	·448
77	·428	·349	·450	·534	·592	·784	·642	·474	·424	·520
78	·364	·431	·392	·486	·630	·640	·648	·454	·318	·485
79	·325	·354	·356	·325	·491	·746	·704	·365	·306	·441
80	·335	·349	·417	·400	·650	·823	·605	·409	·340	·481
81	·284	·357	·431	·433	·642	·854	·612	·352	·306	·475
82	·335	·289	·300	·348	·469	·855	·635	·428	·348	·445
Mean.	·340	·346	·386	·408	·571	778	·646	·418	·341	·471

Unless there be more than is generally admitted in Dr. Balfour Stewart's theory that the occurrence of sunspots is determined or controlled by the positions of the planets, it may be assumed that solar activity is not subject to any important variation of a period equal to one of our years. The monthly mean results of table I may therefore be taken to represent the radiation of a mean sun modified only by terrestrial agencies; and we may proceed to apply the above modification of Pouillet's formula to these monthly means, in order to find out the relative absorbing or scattering effects of dry air, water vapour and dust or haze. The nine months give nine equations, from which, by the method of least squares, I have arrived at the following results:

$$R = 80\cdot^{\circ}434^{*}$$
$$\alpha = \cdot99856$$
$$\beta = \cdot71186$$
$$\gamma = \cdot99393$$

The value of α is identical with that which I obtained from Mr. Hennessey's observations at Mussoorie, while that of β is intermediate between the two values computed from the observations of the 12th and 14th November 1879, at Mussoorie.† Clear dry air of 30 inches pressure absorbs about 4¼ per cent. of the total radiation which falls upon it vertically; while water vapour, with a pressure of 1 inch below and the average vertical distribution, absorbs 29·8 per cent. The effect of dust is less than might be expected, the loss due to this cause in May being apparently only about 6 per cent.; but this is doubtless because the dust is not a simple absorbent, for it scatters or reflects the rays in all directions, and some of these reflected rays reach the globular bulb of the thermometer. An actinometer, arranged to receive parallel rays only, would indicate a much greater loss, on account of suspended matter in the atmosphere.

The monthly means computed by these constants, and their variations from the observed means are as follows:—

Jan.	Feb.	Mar.	Apl.	May	June	Oct.	Nov.	Dec.
62·9°	64·0°	63·4°	62·9°	59 6°	57·4°	58·6°	64·4°	62 2°
—0·7	+0·2	+0·8	+1·3	—0·9	—2·2	+0·2	+1·1	+0·2

The most important difference is in June, when the computed value is 2·2° in defect. This is almost certainly the result of taking the mean vapour tension for the whole month, instead of that for the clear days only The other differences are probably due, in great part, to the unavoidable neglect of variations in the condition of the ground surface.

Applying the formula to the observed mean radiation temperatures for the nine dry months of each year, and taking the proportionate number for dust to be the same each year, we arrive at the following results:—

Year	1876	1877	1878	1879	1880	1881	1882
Corrected radiation temperature.	80·05°	82·60°	82·67°	81·23°	80 23°	79·12°	77·11°

The last minimum of sun spots having occurred in 1878, while 1882 was probably a maximum year, these figures indicate a variation in the solar heat of very considerable range, and in the opposite direction to that

* The degrees of the sun thermometer are only arbitrary units, which cannot be readily converted into units of heat per unit of surface per unit of time.

† Proceedings of the Royal Society, No. 219, page 436.

made out by Mr. Blanford. This contradiction in the results of the two investigations, and the range of the variation here indicated, which amounts to 7 per cent. of the total radiation, make it sufficiently clear that, when every possible allowance is made for disturbing causes, the indications of the black bulb thermometer are an uncertain measure of the sun's radiation. The absorption coefficients for dry air and water vapour, now determined, agree, however, so well with those deduced from Mr. Hennessey's excellent actinometrical observations that they may be accepted with some confidence.

III.—*Notes of a trip up the Dihing basin to Dapha Pani, &c., January and February,* 1882.—*By* S. E. Peal, Esq.

[Received June 24th;—Read August 1st, 1883.]

(With Plates II, III, IV, V and VI.)

The question of the treatment of savage races bordering on, and trading freely with, a civilized power, has always been a difficult one to solve. Whether at the Cape, New Zealand, America, or Central Asia, it has generally involved the paramount power in a series of petty wars, injurious to both sides and ending in the subjection, and too often the degradation, or extermination of the savage.

This contest—inevitable in the end, where the civilized and savage communities are in juxtaposition, is often regretted by the former, and efforts made to mitigate the result, which is well known among Ethnologists.

The treatment of the various savage tribes that surround Asam and offer such marked contrast to the Aryans of the plains, is therefore a matter of some moment. Most of them have no doubt had a common origin, their ancestors having peopled the centre, north, and east of Bengal, of the plains of Asam, whence they have been driven (by the advance of the great Aryan tide) to the hills around.

Looking back into the far past, we should probably see the whole of India a huge and almost interminable tropical forest. Here and there Júm clearings, with villages at some little distance apart, the houses of which, perched on pile platforms, would doubtless be the exact counterpart of those built by these hill men at the present day—and characterized by their length and low eaves. The spear and dao would be in every hand, and the dug-out on every river. To the latter these tribes gave names which survive to our day, and attest their presence. Head-hunting and tattooing would probably be universal, isolating and no doubt differentiating the communities then as now, for the extraordinary number and variety of languages and dialects on the non-Aryan basis, contrasts with the Aryan group, and would point to "head hunting" as the cause around Asam.

A conspicuous feature among these Hill tribes, and one to be expected, is their great intelligence in everything relating to their jungles, customs,